Survival Kit: A Constraint-Based Behavioural Architecture for Robot Navigation

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Abstract. This article presents a constraint-based behavioural architecture for low-level safe navigation, the Survival Kit. Instead of approaching the problem by customising a generic Behaviour-Based architecture, the Survival Kit embodies a dedicated semantics for safe navigation, which augments its expressiveness for the task. An instantiation of the architecture for goal-oriented obstacle avoidance in unstructured indoor environments is proposed. Special attention is given to an environmental feature, the gap, which allows to optimise paths based on immediate ranging data. Experimental results in simulation confirm the capabilities of the approach.

1 Introduction

The motivation for this work is the development of control systems for disposable robots to be applied in hazardous tasks. In those tasks, global localisation and communication mechanisms are reduced or even absent; in addition, robots may get lost or damaged. Another driving force towards the development of simple robot control architectures is the increasing interest on micro and nano-robots. In this sense, the main set of requirements for this work is: the control system should rely as little as possible on localisation mechanisms, complex sensory apparatus, and it should target implementations for simple computational units (e.g. micro-controllers).

Previous work on Behaviour-Based architectures, such as those based on priority (e.g. [2,3]) and action-selection coordination (e.g. [6]) mechanisms either are extremely complex or fail to produce smooth and optimised trajectories. Since only a single behaviour is active at a time, either it includes other skills increasing complexity and reducing modularity, or it will not be goal-oriented (e.g. avoiding obstacles without considering which direction would also benefit a goal seeking behaviour). In voting- (e.g. [8]) and fusion-based (e.g. [1]) Behaviour-Based architectures, the produced action may not satisfy all constituent behaviours, which may reduce the robustness of the system, in case those behaviours are responsible for maintaining robot's safety. In addition, (tedious) tuning of each behaviour contribution to the overall behaviour is usually required, which often compels to choose between robustness and path smoothing.

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Typically, Behaviour-Based architectures are tackled in a holistic perspective, where the same semantics is used in all parts of the control system, such as safety keeping and task-achieving parts. This paper approaches the problem differently, it assumes that different semantics are required at each level. In this sense, this work introduces an architecture, the Survival Kit (SK) architecture, whose semantics is specially designed for safe navigation, delegating task-achieving requirements to upper-layers, which can be implemented by any other architecture (not necessarily a Behaviour-Based one). The coordination mechanism implemented in the SK architecture is based on constraints, which are added by several reflexes running in parallel, according to their skills. This type of *cooperation by negation* guarantees that the resulting action does not disagree with any of the reflexes. Although this feature is essential for safe navigation, it may be restrictive for task-achieving behaviours.

As it will be shown, the semantics of the SK will allow the implementation of a simple yet robust goal-oriented obstacle avoidance method, which taking into consideration the target implementation, i.e. disposable robots, is capable of competing with the most popular methods, such as *Dynamic Window Approach* [4], *Curvature Velocity Method* [9], *VFH+* [11], *Nearness Diagram* [7], and *Potential Fields* based approaches [1]. Since the obstacle avoidance method herein proposed is supported by a behavioural architectural framework, it is potentially more generalisable and modular than the previously referred algorithmic based approaches.

2 The Survival Kit Architecture

The SK architecture intends to be used as the bottom layer of a robot control system, providing it with safe navigation capabilities. Thus, everything required

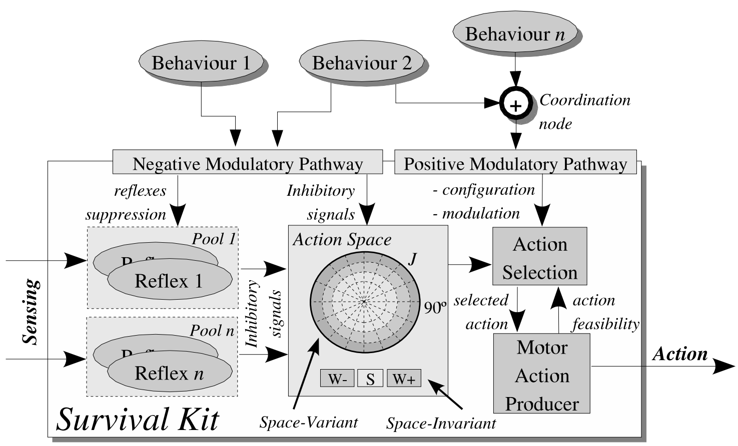

Fig. 1. The Survival Kit Architecture. Behaviours are exemplifying a task-achieving upper-layer.